



Gaia

Stereoscopic Census of our Galaxy

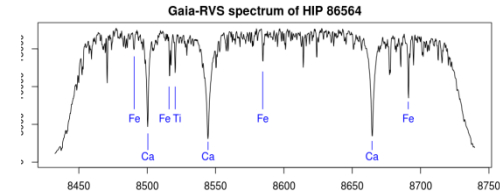
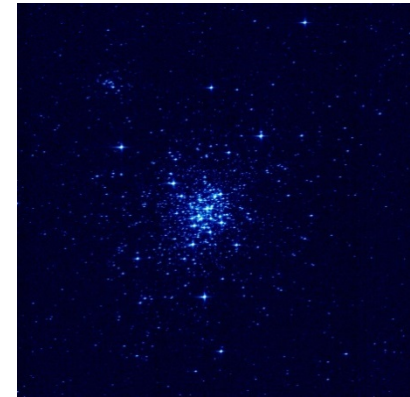
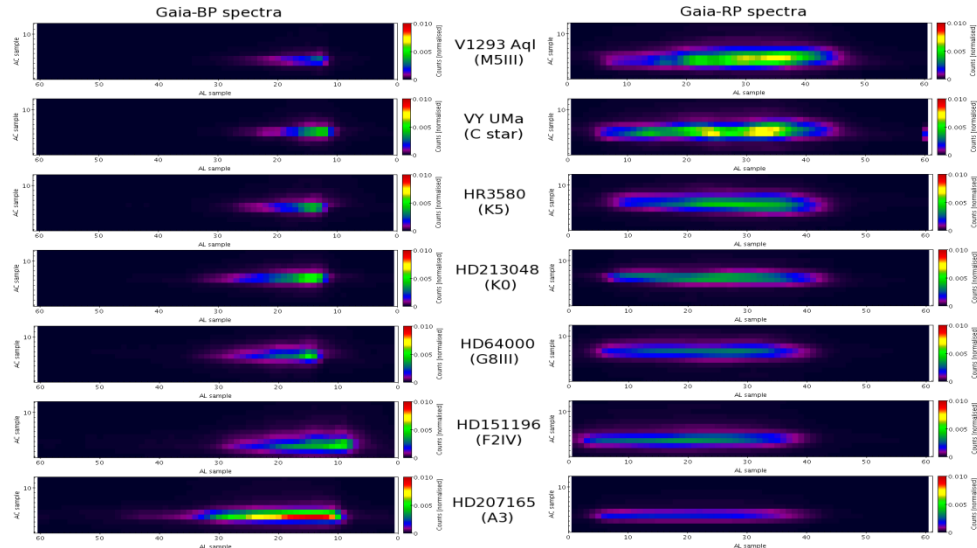
<http://gaia.ac.uk>

one billion pixels for one billion stars

one percent of the visible Milky Way

<http://blogs.esa.int/gaia/>

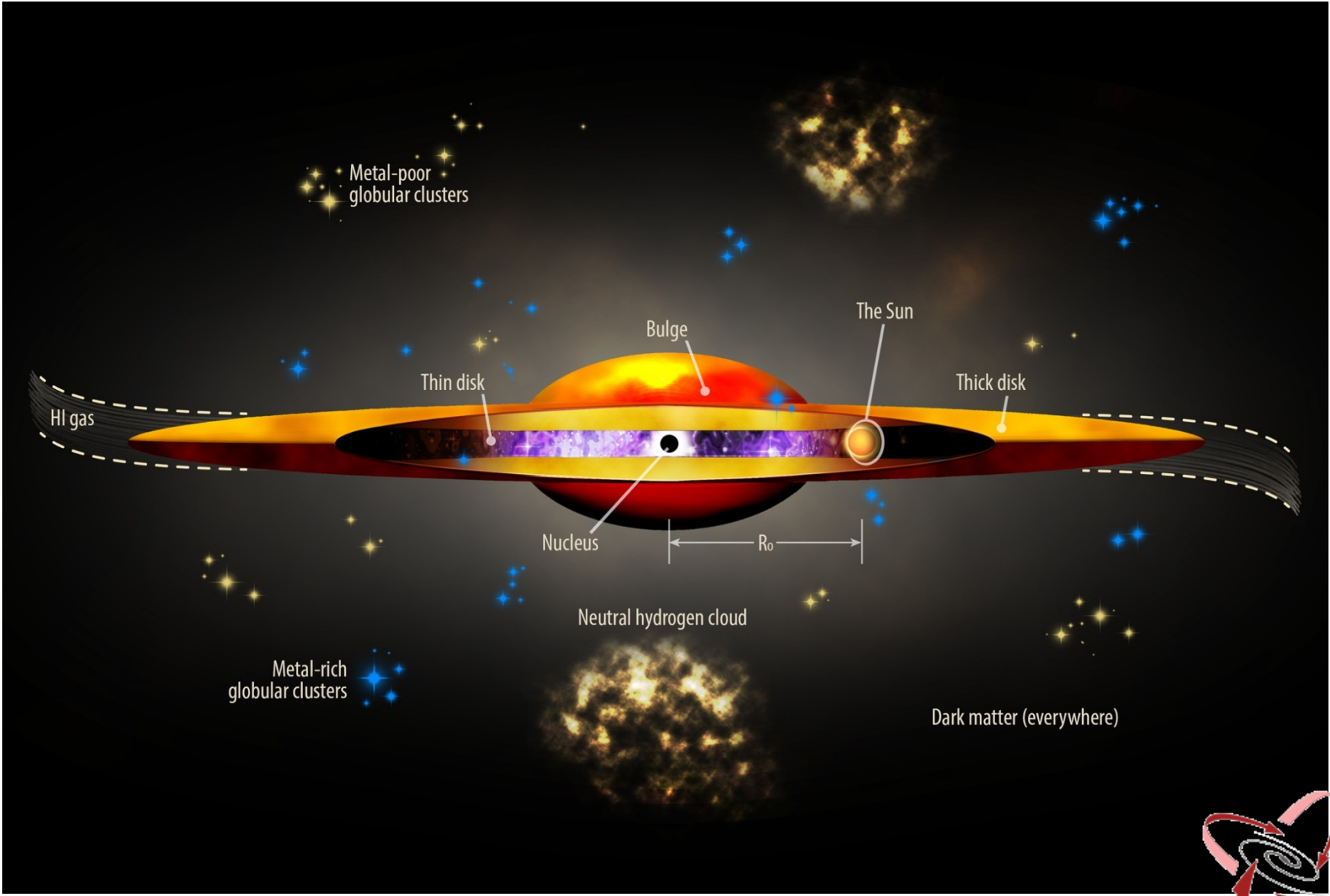
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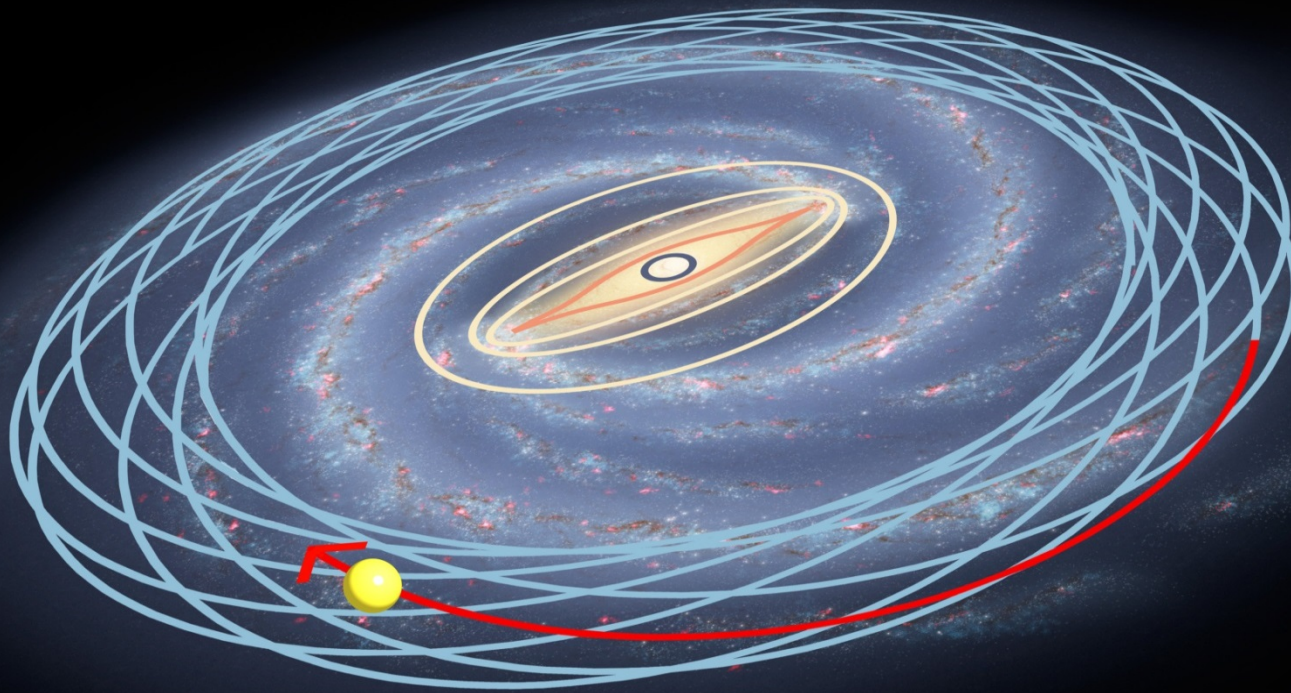
What is Gaia?

- Gaia is a hands-on real-science classroom and public science education and discovery machine
- The largest camera yet in space – one billion pixels
- Precise images deliver precise positions for stars
- Overtime, via parallax, this provides precise distance
- This maps the Milky Way, finds planets, weighs dark matter, tracks the creation of the chemical elements, the formation of the Galaxy, killer asteroids...
- Gaia discoveries will be public – we are building a public involvement system for you
- Gaia is in-orbit, started science observations July 2014

Taking the census of the Milky Way Galaxy

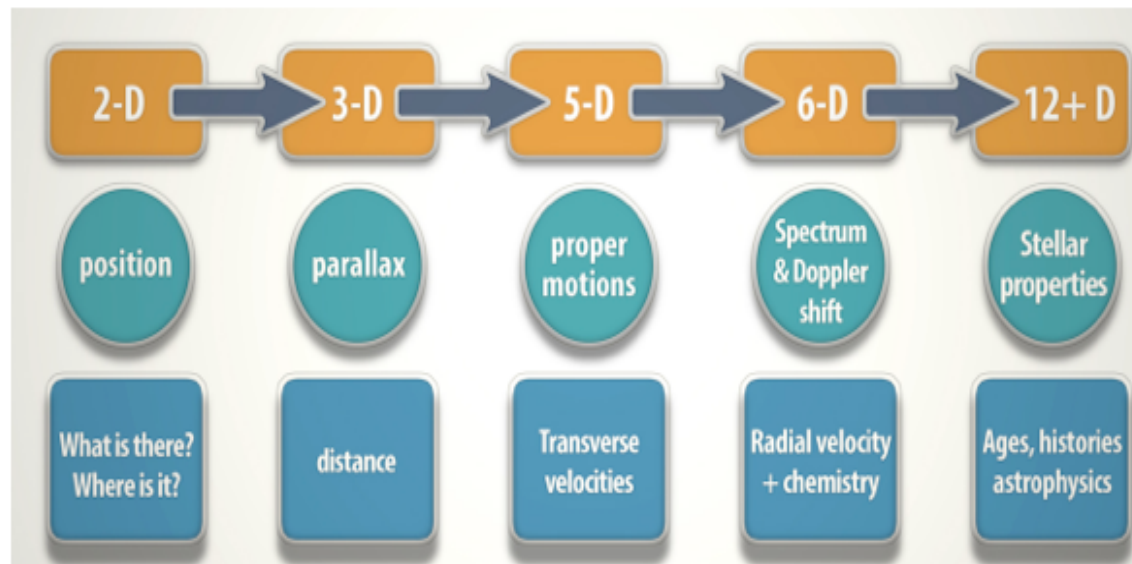


A galaxy is a gravitational potential which supports orbits. Stars occupy orbits, and are fossils, retaining memory of the history of chemical evolution prior to their formation. With astrometry, to provide orbits, chemistry to probe history, we deliver Galactic archaeology. And very much more: streams, accretion, dark matter potential, GR, killer asteroids, ...



How does one study the Milky Way?

scientific discovery involves knowing an object exists, how it moves, its composition



Stellar orbits, star formation history, origin of the elements, Galaxy assembly, dark matter, cosmological initial conditions, fundamental physics, solar system(s), ...

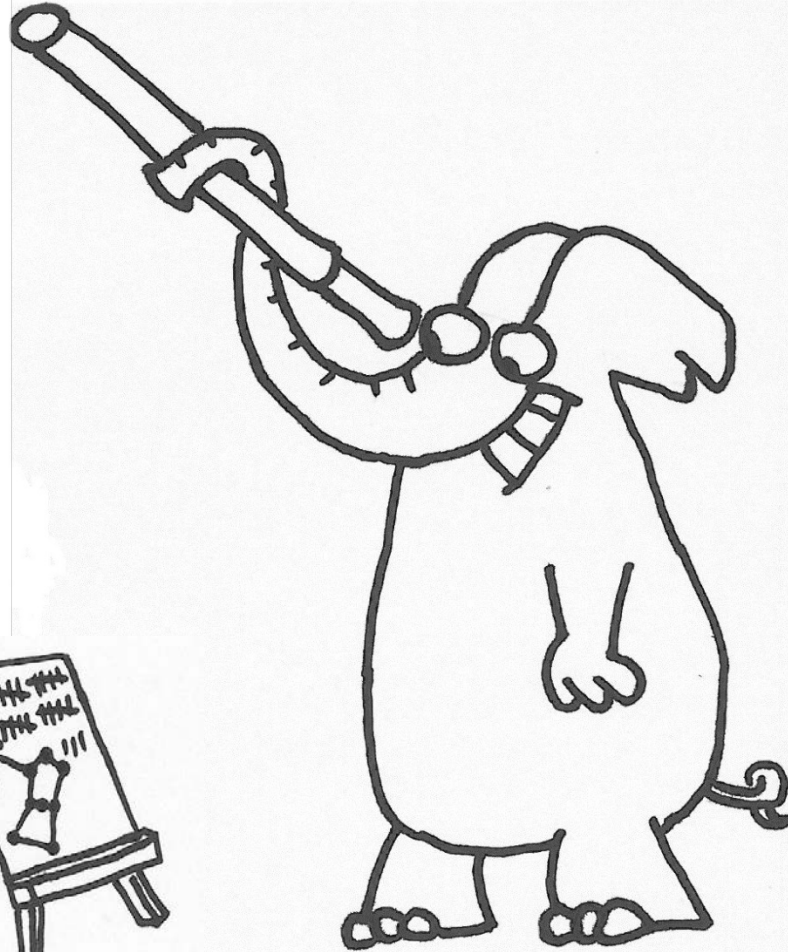
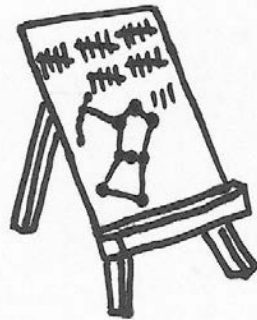
Position
Distance
Size
Colour
Motion
Rotation?
Shape
Texture
Brightness
Changes
...
Taste
Sound
Touch
Smell...

Taking the census of the Milky Way Galaxy

There is an elephant in the astrophysics room:
all distances depend on too few, inaccurate, stellar parallaxes

The distance scale
is the *weak link*
in modern astrophysics

I gave my friend an elephant
He said: "thanks"
I said: "don't mention it"



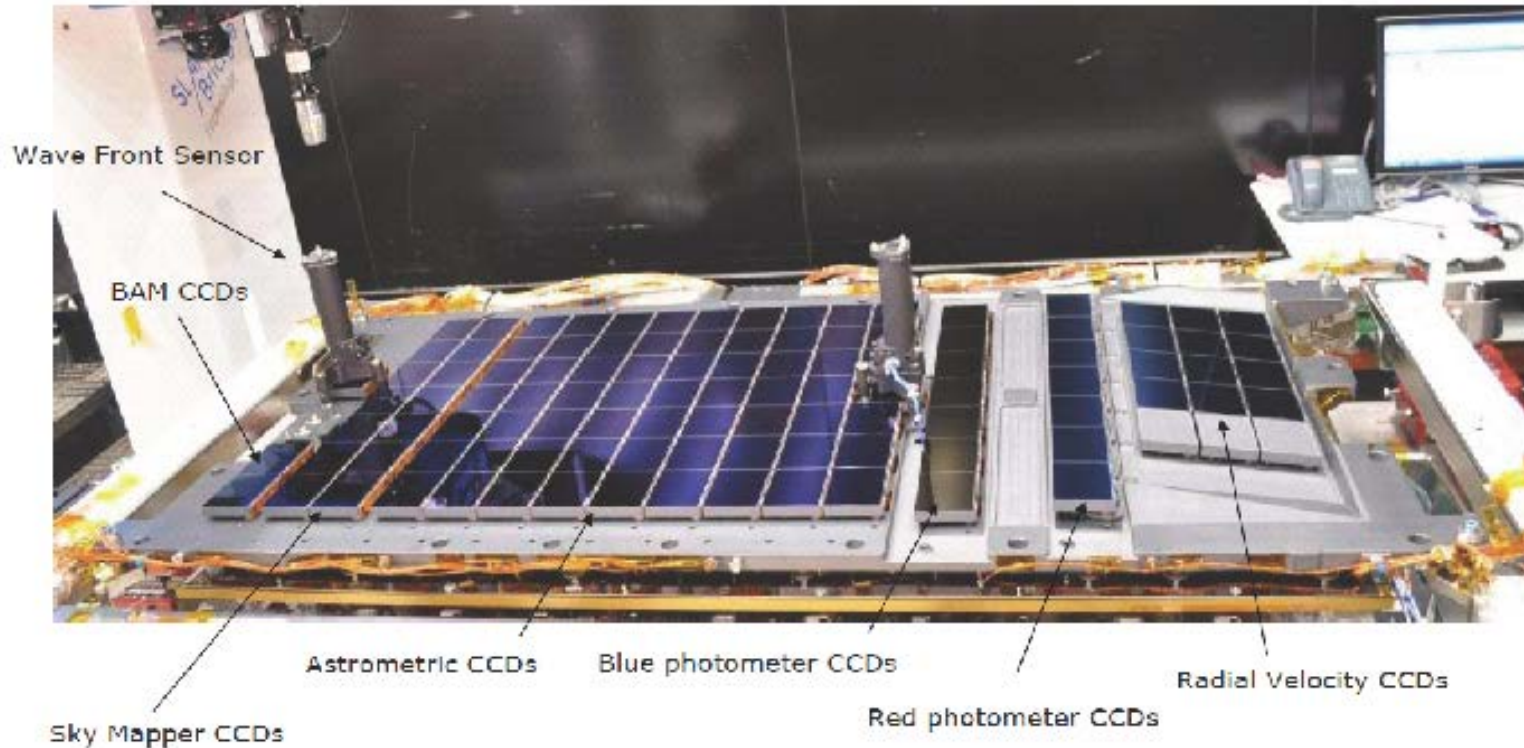
Thanks to Ian for the elephant



How Gaia works

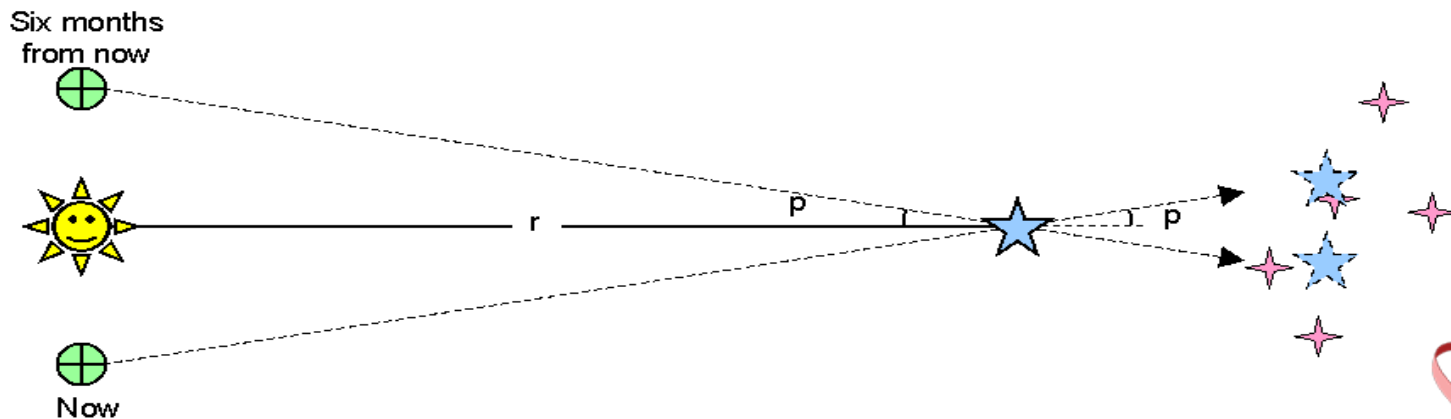
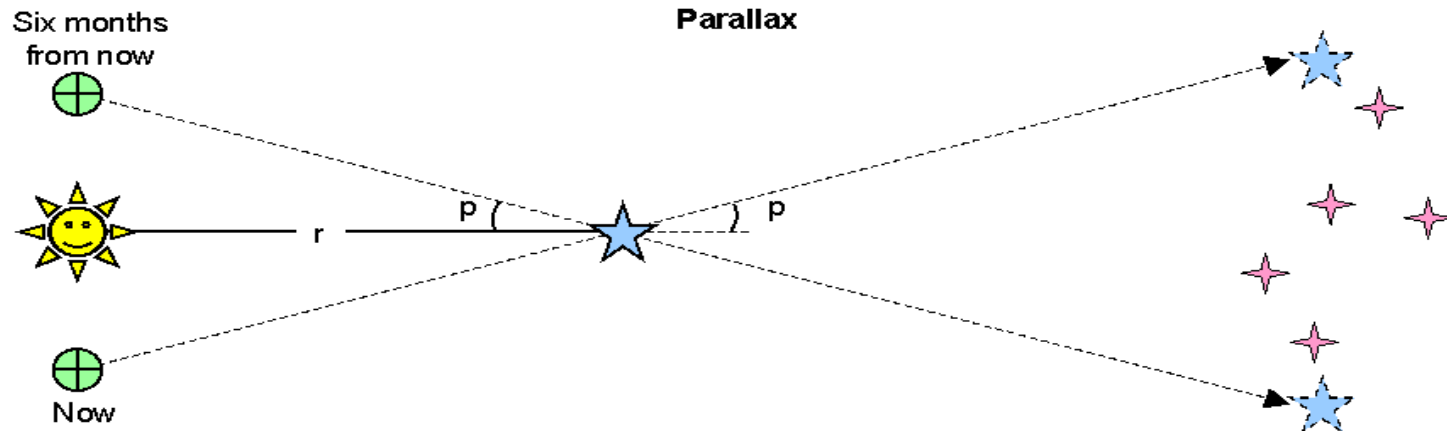


Focal Plane Assembly

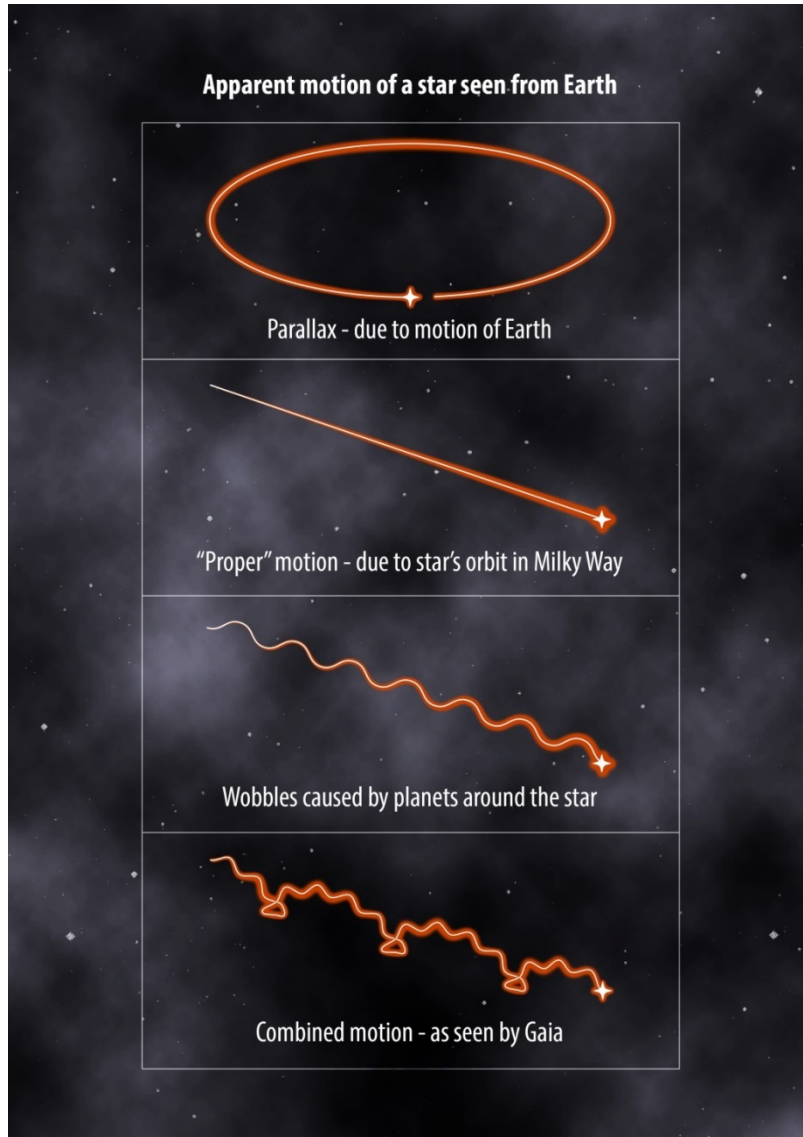


Data flow: 50Gb/day for 5-6 years; total processed data and archives → 1PByte
Computational challenge : 1.5×10^{21} FLOP – and highly sophisticated algorithms
Total measurements: 1,000,000,000,000

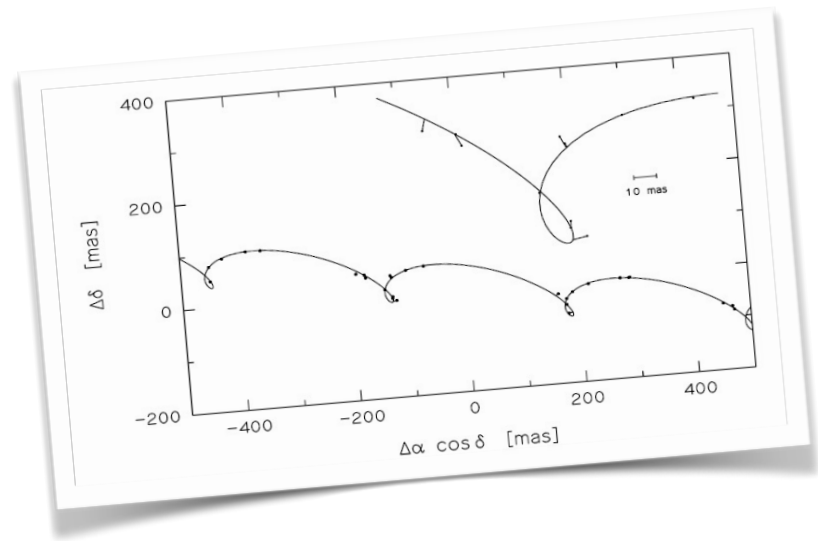
recall that parallax provides distance



What will Gaia see as stars move?



These are real Hipparcos measures



Gaia accuracy is 100 times better
Gaia precision is the same as
locating a euro coin on the **Moon**

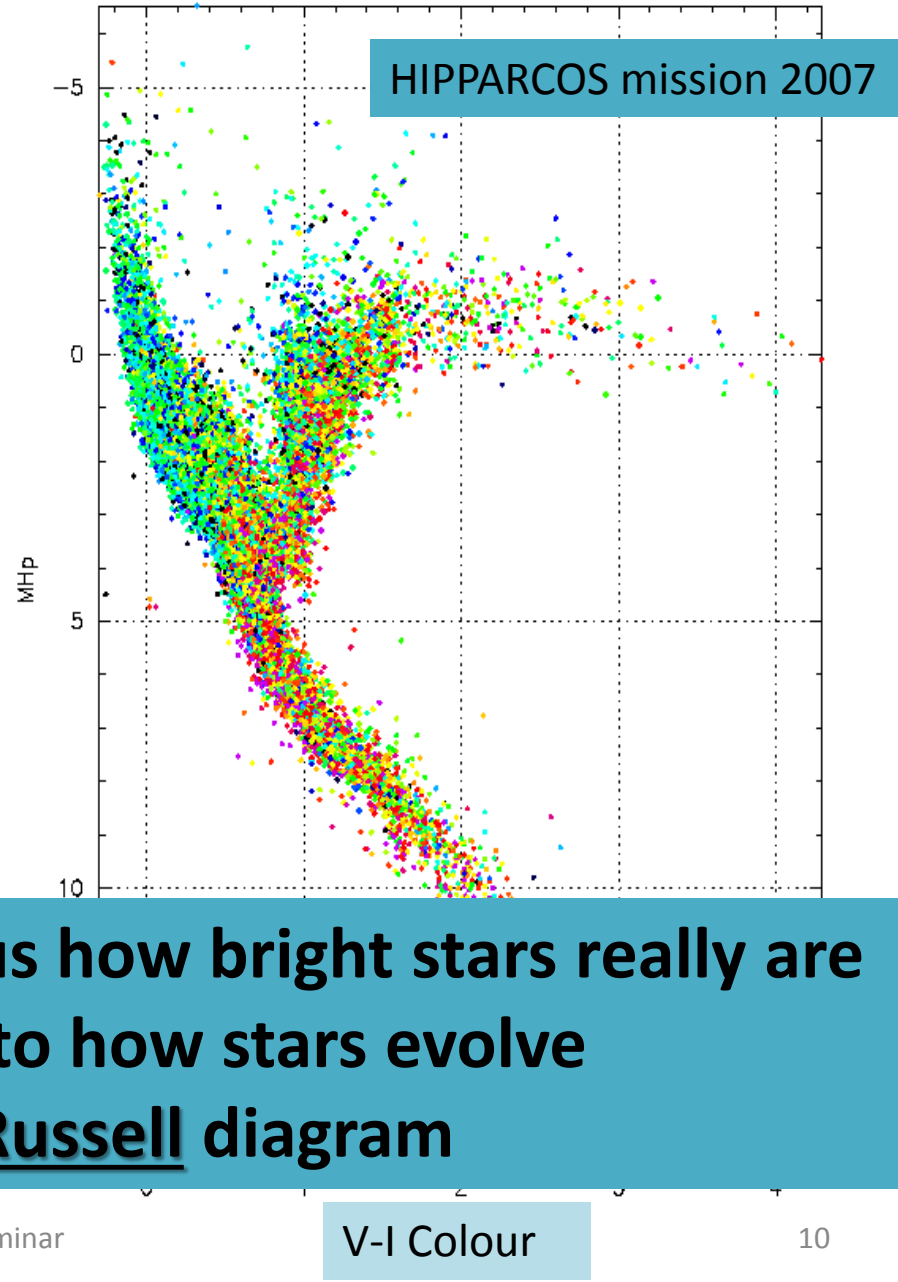
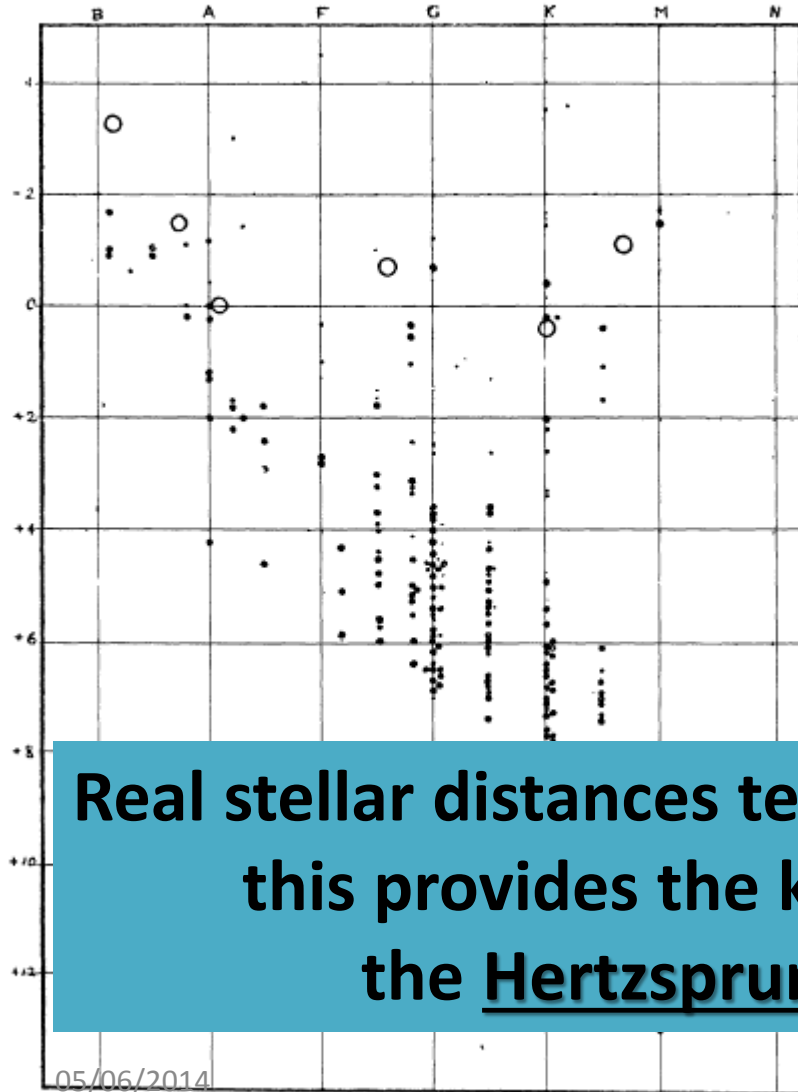


Why is astrometry interesting?

Henry Norris Russell

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parallax is less than 42 per cent of the parallax itself, so that the probable error of the resulting absolute magnitude is less than $\pm 1^m.0$.



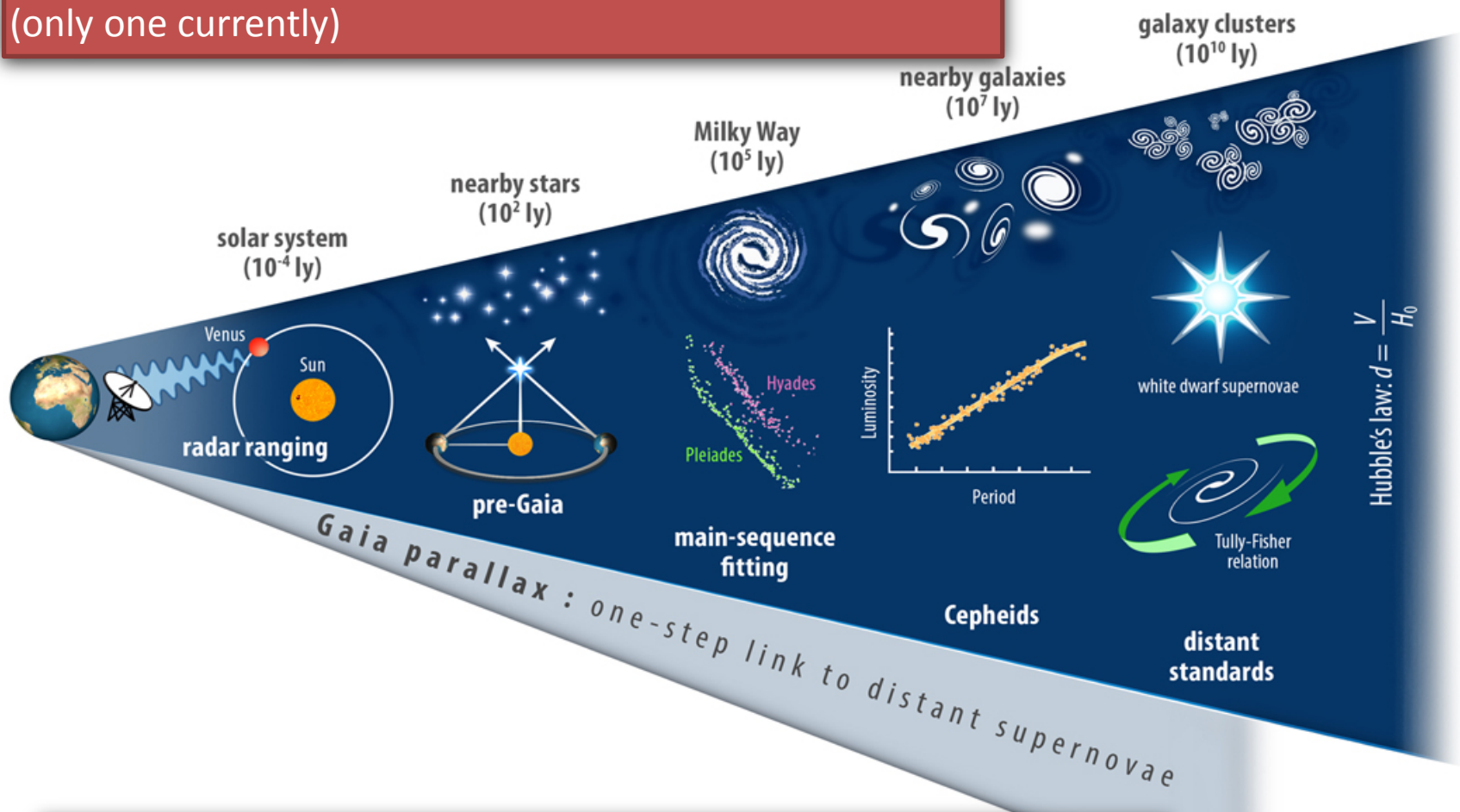
Real stellar distances tells us how bright stars really are
this provides the key to how stars evolve
the Hertzsprung-Russell diagram

FIGURE 1.

Taking the census of the Milky Way Galaxy

Precision Cosmology with Gaia

Precision calibration from parallaxes of 9000 Cepheids
(only one currently)



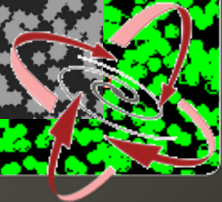
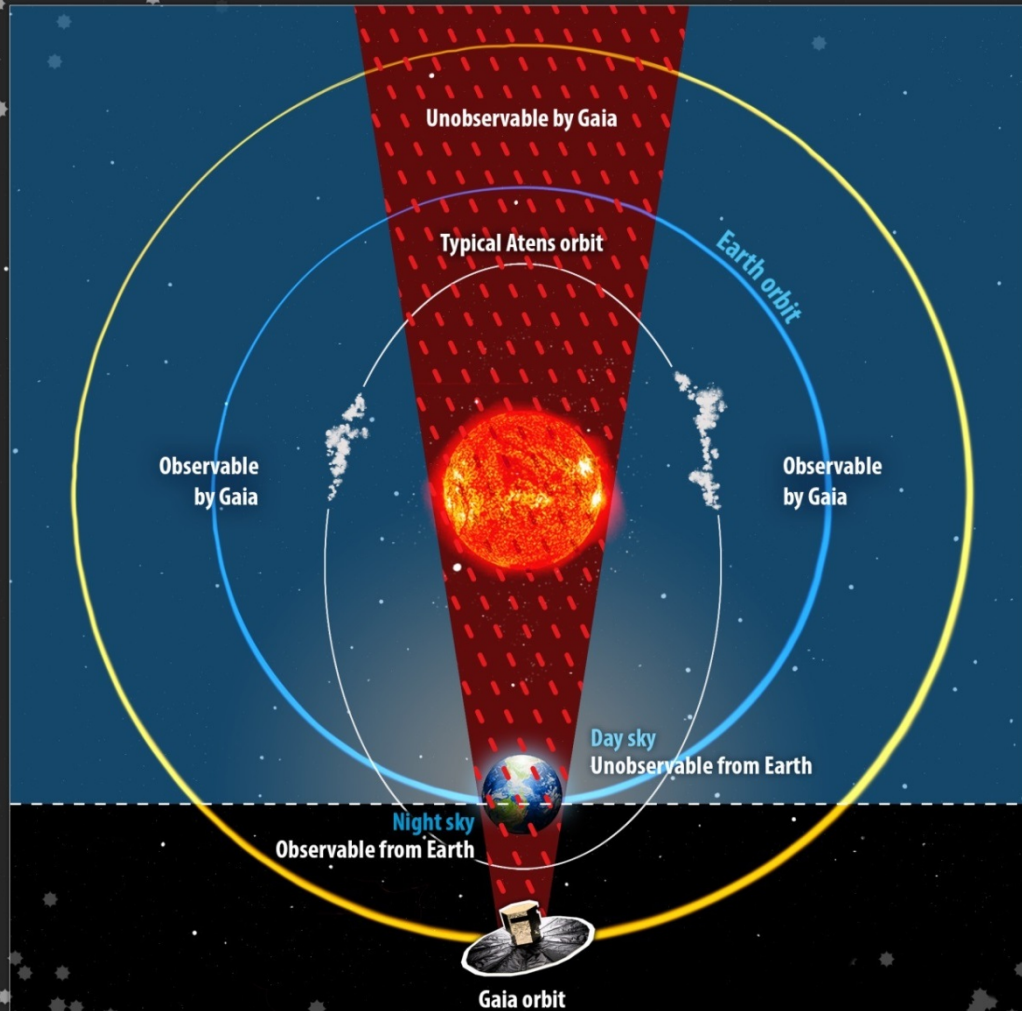
Gaia real-time science Alerts

Find 10000 nearby supernovae within Cepheid overlap regime



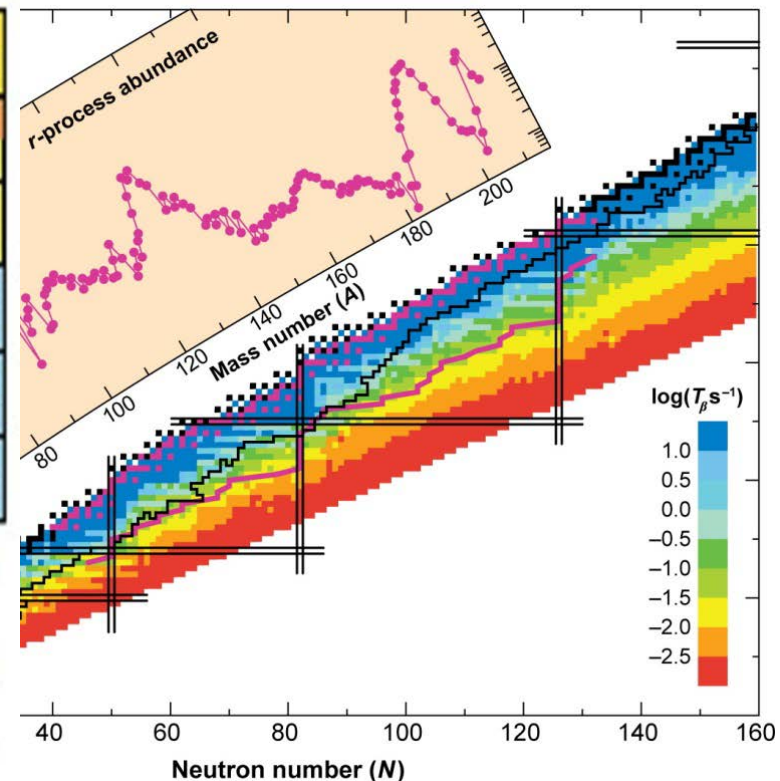
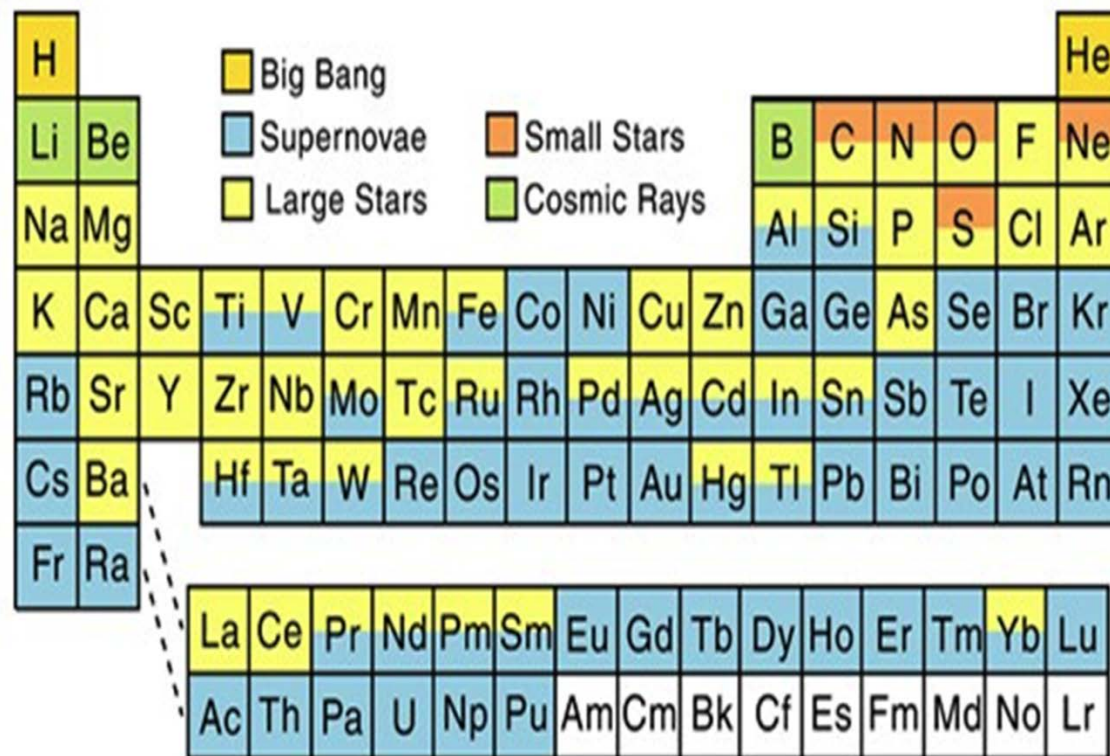
Taking the census of the Milky Way Galaxy

GAIA is a Nemesis survey



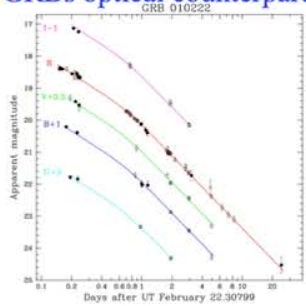
When: tracking stardust: origins of the chemical elements

- H, He & Li are ashes from the Big Bang. All other elements are created in (or by) stars, dispersed through supernovae and stellar winds, becoming available to form new stars, planets, and people.
- The different creation processes: iron-peak (Fe, Cr..), alpha (C, O, Mg, Ca, Si..), light (N, F), proton capture (Sc, V), rapid- (Ba, Eu) or slow(Sr)-neutron capture ... correspond to stars of different lifetimes, and so the elements form a cosmic clock, which allows us to decode the sequence of events which began 13Gyr ago, and which continues today

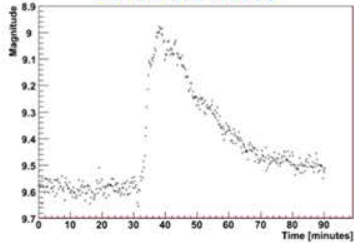


Gaia will also observe the transient sky

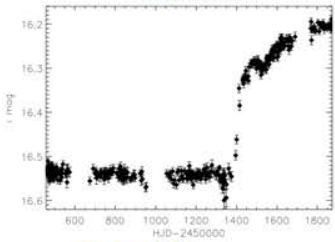
GRBs optical counterparts



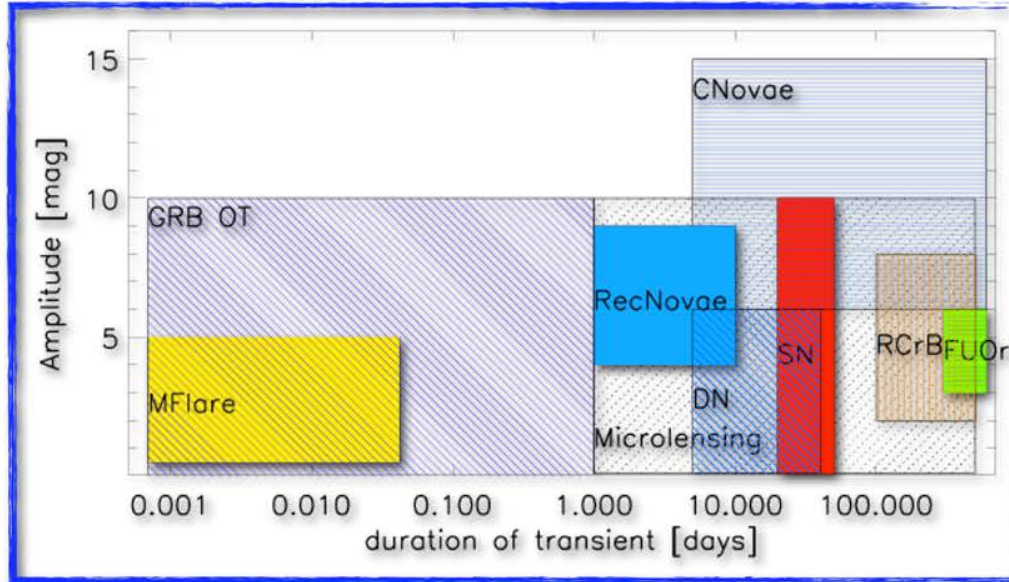
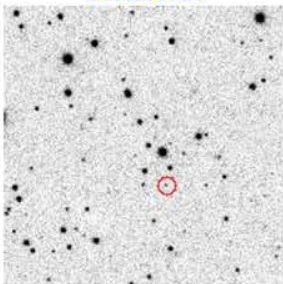
M-dwarf flares



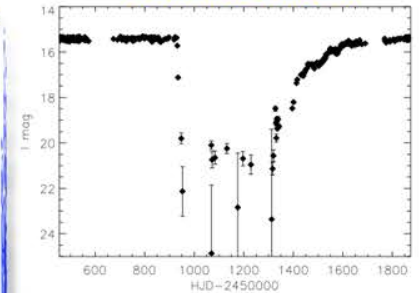
Be stars



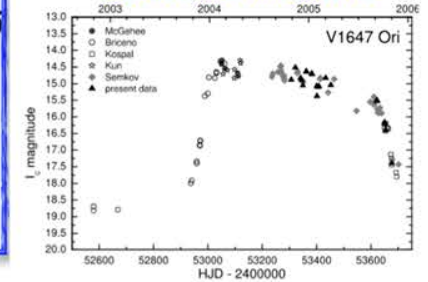
Asteroids



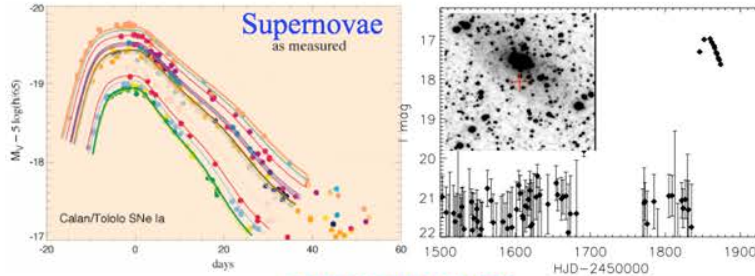
R Coronae Borealis



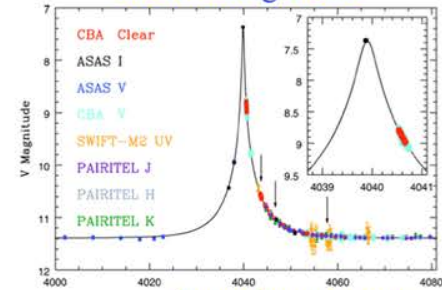
FU Orionis and similar



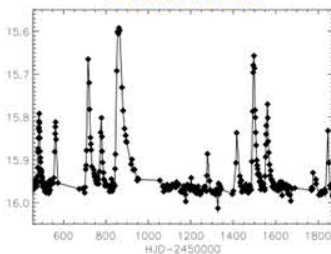
Supernovae as measured



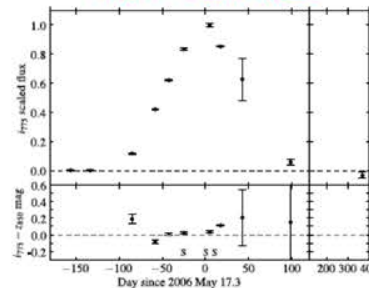
Microlensing events



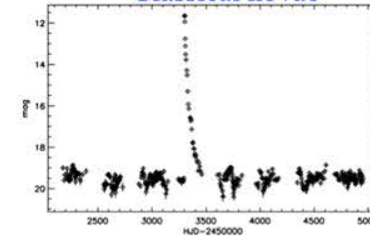
Dwarf novae



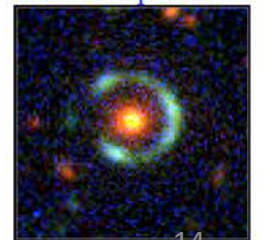
NEW THINGS??



Classical novae



Lensed supernovae



Gaia science: when and to whom?



Thanks to Sophie for the image

- Science results to professionals after two years
- Science results – new sources, supernovae ... to the public in late summer 2014. For schools, amateurs, anyone....
- gaia.ac.uk will be a simple interface to all Gaia science:
- material describing the discoveries
- links to the robotic telescope for schools: Faulkes, Liverpool, Las Cumbres
- Gaia animations to introduce Gaia science
- A portal to record YOUR data for science use



a few Gaia numbers

- One billion stars = 1% of the Milky Way's stars
- One billion pixel camera
- Total project cost 960Meuro
- Project lifetime: 1993 – 2023
- Accuracy – 10microarcsec = 10^{-10} rad: = thickness of a human hair at 1000km
- Einstein light bending at the Sun's edge is 1750000microarcsec
- Must know Gaia's location within 150m: it is about 1.5Mkm away
- Gaia will travel about 16Mkm over 5 years
- Satellite global timing network extended to picosecs for Gaia
- In one picosec light travels 0.3mm
- Satellite communications link is 300W, total power use 1276W
- 100Tb raw data collected at May 17, 25 billion transits
- 2 telescopes, 35m focal length, rectangular mirrors
- 3.5M hours of work to study, design & build = 300people x 7 years
- 400 scientists working on data processing
- Over 30,000 mission documents in archive
- Launch burned 225 tonnes of kerosene+oxygen in 5 minutes
- In orbit micro-propulsion system ejects 1 microgram of nitrogen per thrust
- Gaia measures 40 million stars per day on average
- 10^{13} individual position measurements; 10^{10} unknowns, 100's of iterations

PLUS: 1million galaxies; 500,000 QSOs; 10,000 Supernovae – in real-time; 250,000 asteroids; 15,000 extra-solar planets; 200,000 white dwarfs; 50,000 brown dwarfs, the new,